

Name Mr. Shank

Period AP1,2,3

(10 total)

Quiz 3: Periodic Properties

(3)

1. List the following atoms in order of **increasing** atomic radius: He, N, Na, F, B, O

He < F < O < N < B < Na

(3)

2. List the following atoms or ions in order of **decreasing** radius: H, Ca²⁺, Ar, Si, Ca, Si⁴⁻

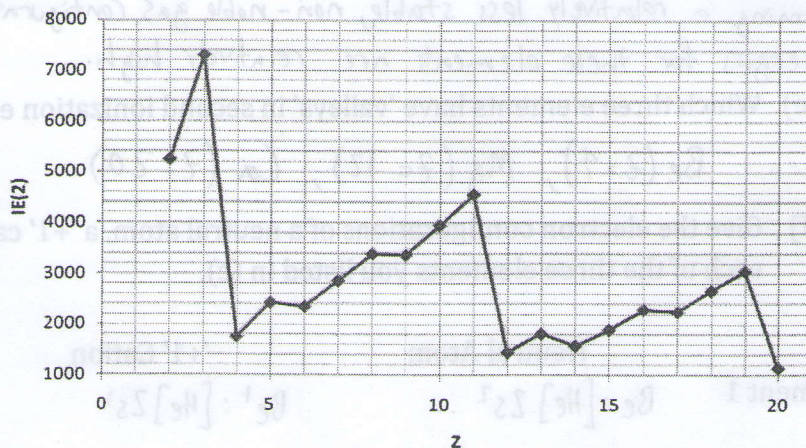
Ca < Si⁴⁻ < Si < Ar < Ca²⁺ < H

Would also accept

3. An element's first ionization energy (IE₁) is the energy needed to remove one electron from a neutral atom of that element. For homework, you looked at the first ionization energies of the first 54 elements: **Ex. He → He⁺**

An element's second ionization energy (IE₂) is the energy needed to remove an electron from a '+1' cation of that element. Below is a table and plot of the second ionization energies of the first 20 elements: **Ex. He⁺ → He²⁺**

Z	IE ₂	Z	IE ₂
1		11	4560
2	5251	12	1450
3	7300	13	1820
4	1757	14	1580
5	2430	15	1904
6	2350	16	2297
7	2860	17	2250
8	3390	18	2666
9	3370	19	3052
10	3950	20	1145



(1)

- a) Why is there no IE₂ for hydrogen?

Neutral hydrogen only has one electron, so H⁺ has no electrons. Thus, H⁺ can not lose another electron to form H²⁺.

(3)

- b) Which three elements have 'peaks' in second ionization energy?

Li (Z=3), Na (Z=11), K (Z=19)

(25 total)

- (19) c) Give the electron configurations of a neutral atom, a '+1' cation, and a '+2' cation for each of the three elements you listed in (c).

Ex.	Neutral Atom	'+1' Cation	'+2' Cation
	O: [He]2s ² 2p ⁴	O ⁺ : [He]2s ² 2p ³	O ²⁺ : [He]2s ² 2p ²
Element 1	Li: [He]2s ¹	Li ⁺ : [He]	Li ²⁺ : 1s ¹
Element 2	Na: [Ne]3s ¹	Na ⁺ : [Ne]	Na ²⁺ : [He]2s ² 2p ⁵
Element 3	K: [Ar]4s ¹	K ⁺ : [Ar]	K ²⁺ : [Ne]3s ² 3p ⁵

- (2) d) Based on your answer to (c), why do you think the second ionization energy is relatively so high for these three elements?

The "+1" cations of each of these elements have noble-gas electron configurations, which are extremely stable. It costs a lot of energy to remove an extra electron, forming a relatively less stable, non-noble gas configuration. Thus, the second ionization energies for these elements are relatively high.

- (3) e) Which three elements have 'valleys' in second ionization energy?

Be (Z=4), Mg (Z=12), Ca (Z=20)

- (19) f) Give the electron configurations of a neutral atom, a '+1' cation, and a '+2' cation for each of the three elements you listed in (c).

	Neutral Atom	'+1' Cation	'+2' Cation
Element 1	Be: [He]2s ²	Be ⁺ : [He]2s ¹	Be ²⁺ : [He]
Element 2	Mg: [Ne]3s ²	Mg ⁺ : [Ne]3s ¹	Mg ²⁺ : [Ne]
Element 3	Ca: [Ar]4s ²	Ca ⁺ : [Ar]4s ¹	Ca ²⁺ : [Ar]

- (2) g) Why do you think the second ionization energy is relatively so low for these three elements?

The "+1" cations of each of these elements only have one more electron than a nearby noble-gas. Thus, it costs relatively little energy to remove an extra electron in forming the "+2" cation, which has a very stable noble gas electron configuration.

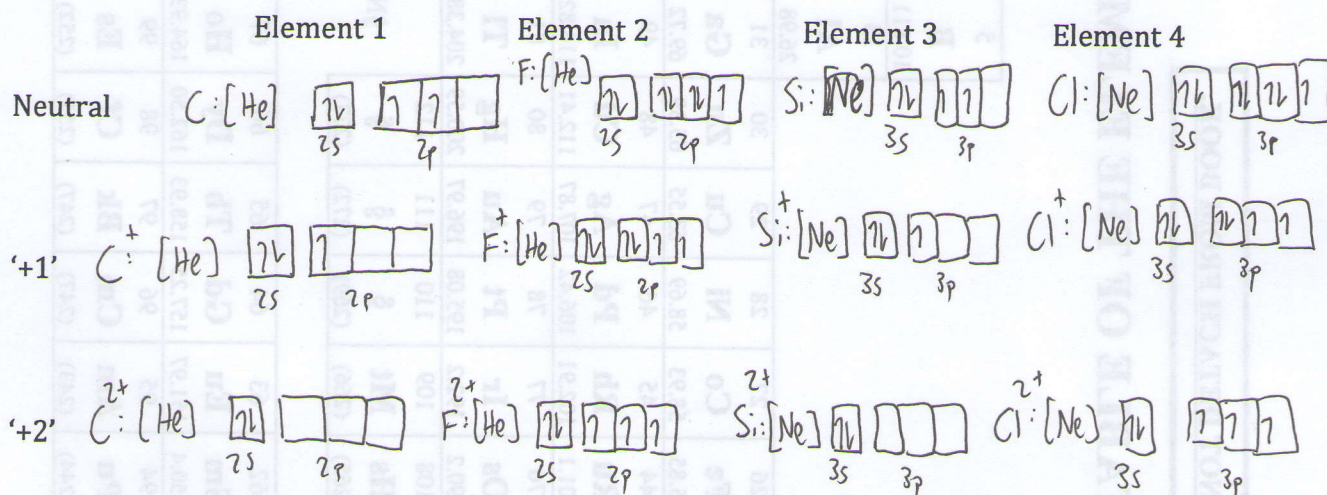
Extra Credit:

We expect that it is harder to remove electrons that are closer to the nucleus, so the second ionization energy should decrease going down a column and increase from left to right across a row. This is mostly true, but there are a few exceptions ...

1. List the four elements that have a lower second ionization energy than the element immediately to their left on the periodic table $C (Z=6)$, $F (Z=9)$, $Si (Z=14)$, $Cl (Z=17)$

Be, Mg, Ca

2. Draw **box diagrams** for a neutral atom, a '+1' cation, and a '+2' cation for each of the four elements you listed in (1).



3. Using your answer to (2), explain why these four elements are exceptions to the general trend in second ionization energy.

Atoms are especially stable when their valence orbitals are half-filled or fully filled. We saw this in writing the electron configurations for Cr, Cu, Ag, and Au.

C and Si both go from singly filled p valence orbitals to fully filled s orbitals upon losing an electron from their "+1" cations. Since the C^{2+} and Si^{2+} electron configurations are especially stable, their second ionization energy is relatively low.

F and Cl both go from p^4 valence orbitals to half-filled p orbitals upon losing an electron from their "+1" cations. Since the F^{2+} and Cl^{2+} electron configurations are especially stable, their second ionization energies are relatively low.